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TO ALL WHOM IT MAY CONCERN:

Be it known that WE, MICHAEL MOULIN and JIANBING HUANG, citizens of Switzerland and the United States, respectively, residing in Switzerland and the United States , whose post office addresses are Rue d'En Haut 16, Apples, Switzerland, CH-1143 and 1057 Daniels Farm Road, Trumbull, Connecticut 06611, respectively, have invented an improvement in a:

METHOD AND APPARATUS FOR LASER-INDUCED THERMAL TRANSFER PRINTING

of which the following is a specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to laser-ablation transfer printing processes and laser-induced melt-transfer printing processes. More specifically, the present invention relates to techniques for providing contact between a donor sheet and an acceptor sheet in laser-ablation transfer processes and laser-induced melt-transfer processes, and for conducting laser-scanning in connection therewith.

2. Background Information

[0002] Laser-ablation transfer printing and laser-induced melt-transfer printing (collectively referred to herein as laser-induced thermal transfer printing) involve the transfer of a material

from a donor sheet to an acceptor sheet to form a representation of an image on the acceptor sheet. During this transfer, it is necessary for the donor sheet and acceptor sheet to be held in contact with one another. The transfer of material is thermally induced by the application of a scanning laser beam at selected points across the donor sheet-acceptor sheet combination.

[0003] Laser-induced thermal transfer printing is well known to be useful for producing halftone color proofs, films, printing plates and other printing forms. Specifically, this type of transfer printing is known to be particularly useful for applying an ink-accepting coating onto a seamless sleeve having a hydrophilic surface, and also for applying an ink-repelling material onto an ink-accepting surface. Processes for using laser-induced thermal transfer printing to make printing plates and other printing forms are well known and are described for example in U.S. Patent Nos. 3,964,389 and 5,819,661, which specifically address laser-ablation transfer printing and laser-induced melt-transfer printing, respectively.

[0004] The composition of the donor sheets and acceptor sheets used in connection with laser-induced thermal transfer printing is likewise well known in the art. For example, U.S. Patent No. 5,757,313 discusses donor elements containing polymerization initiators, and U.S. Patent No. 5,238,778 discloses donor elements containing photo-curable compositions. U.S. Patent No. 5,607,810 discloses a peel-apart assembly which can include donor elements having transferable dyes and acceptor elements having non-proteinic hydrophilic surfaces. U.S. Patent No. 5,401,606 describes a laser-induced melt transfer process in which a melt viscosity modifier is utilized to better facilitate the melt transfer process between the donor and acceptor.

[0005] In laser-induced thermal transfer printing processes, it is known that the donor sheet and acceptor sheet must be held in contact with one another with relatively uniform contact pressure across the donor-acceptor combination, to insure uniform transfer characteristics for a specified level of laser energy. In connection with such printing processes, donor sheets and acceptor sheets traditionally have been pre-assembled into a subassembly. The donor-acceptor subassembly has been attached to either an internal drum or an external drum for laser imaging. Once the laser imaging has been completed, the donor sheet and the acceptor sheet have been separated from one another. In printing plate-making applications, the acceptor typically has been used as a printing plate.

[0006] For certain laser-induced thermal transfer printing applications, it has been considered desirable to assemble donors and acceptors directly on the imaging device. Where an external drum arrangement has been used in such techniques, the acceptor sheet typically has first been affixed to the outer circumference of the drum, and the donor sheet has then been secured over and substantially coextensively with the acceptor sheet. Certain laser-induced thermal transfer printers of the prior art, such as those disclosed in U.S. Patent No. 5,446,447, have used vacuum drum arrangements to achieve the requisite sufficiently uniform contact between the donor sheet and acceptor sheet. Such vacuum drum arrangements have added significant cost, size, and complexity to the printers in which they are used, however.

[0007] Certain other laser-induced thermal transfer printers of the prior art, such as those disclosed in U.S. Patent No. 5,764,268, have provided contact between the donor sheet and the acceptor sheet without the need for a vacuum drum arrangement. Such laser-induced thermal

transfer printers have utilized dedicated tensioning mechanisms and clamping devices to apply tension to the donor sheet, and to draw the donor sheet into contact with the acceptor sheet.

[0008] In addition to laser-induced thermal transfer printing techniques, other types of thermal transfer printing utilizing the assembly of donors and acceptors directly on the imaging device are also well known in the art. For example, U.S. Patent No. 5,072,671, the contents of which is incorporated herein by reference, discloses an apparatus and method for transferring an imaged donor layer generated by a thermal recording head from an intermediate support to an acceptor via a reproducing means. Specifically, this transfer is accomplished by transferring meltable particles from the donor layer onto a deformable acceptor surface. U.S. Patent No. 4,958,564 describes a method of using a rigid thermal head to transfer a donor substance from a donor support to an intermediate surface, and of then transferring the donor substance from the intermediate surface to the final acceptor. This patent also discloses the technique of transferring to a rigid printing form the donor substance which remains on the donor support after the above-described transfer of the donor substance from the donor support to the intermediate surface.

[0009] U.S. Patent No. 4,804,975 describes a thermal dye transfer apparatus which absorbs heat from a laser light. Donor and acceptor sheets are hard pressed into close contact in the projection area by a pressure plate.

[0010] Therefore, in view of the above-described examples and limitations in the existing art, a need has arisen for further laser-induced thermal transfer printing techniques in which donors and acceptors are assembled directly on the imaging device. A need has also arisen for such techniques which do not require vacuum drum arrangements or dedicated tensioning

mechanisms and clamping devices to maintain the requisite contact pressure across the donor sheet-acceptor sheet combination. A need has also arisen for such techniques which eliminate the need for manual separation of donor sheets and acceptor sheets. A need has also arisen for such techniques which eliminate the need for disposal of donor supports once the printing process has been completed, and in which donor supports instead can be recoated with donor material, thereby reducing waste and cost. A need has also arisen for such techniques in which donor sheets can be conveniently supplied on rolls.

SUMMARY OF THE INVENTION

[0011] The details of the preferred embodiments of the present invention are set forth in the accompanying drawings and the description below. Once the details of the invention are known, numerous additional innovations and changes will become obvious to one skilled in the art.

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[0012] In accordance with the present invention, an apparatus and method are provided for achieving substantially intimate rolling contact between a portion of a donor sheet and a portion of an acceptor element in a laser-induced thermal transfer printer which comprises a laser imaging head. The system includes a rotatably mounted cylindrical drum, an acceptor element which may be a sleeve-type acceptor or an acceptor sheet affixed to and supported by the cylindrical drum, a rotatably mounted dispensing roller for dispensing a donor sheet, and a rotatably mounted receiving roller for receiving the donor sheet, so that the donor sheet is extended between the dispensing roller and the receiving roller. The system also includes a plurality of rotatably mounted contact rollers configured to bring a portion of the donor sheet extended between the dispensing roller and the receiving roller into contact with a portion of the

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acceptor element. The laser imaging head does not contact either the donor sheet or the acceptor element.

[0013] The term "sleeve-type acceptor" as used herein is intended to indicate a substantially cylindrical hollow tube having an outer surface appropriate for a specific application. If the application is an image-carrying printing form for use on a lithographic printing machine, the outer surface of a sleeve acceptor should have an ink-affinity opposite to the ink-affinity of the transferred material from a donor ribbon. Examples of such sleeve-type acceptors can be found in U.S. Patent No. 5,379,693 and U.S. Patent No. 5,440,987, each of which is herein incorporated by reference. In the apparatus of the present invention, a sleeve-type acceptor is preferably supported by a cylindrical core having a radial expansion means or by two end caps mounted on both sides of the sleeve acceptor. Such mounting mechanisms are known in the art, as described, for example, in U.S. Patent No. 6,038,975 and U.S. Patent No. 5,481,975.

[0014] In accordance with an exemplary embodiment of the present invention, the acceptor element is affixed to the external surface of the cylindrical drum.

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[0015] In accordance with another exemplary embodiment of the present invention, the contact rollers comprise a first and second contact roller in contact with the cylindrical drum, and configured so that the portion of the donor sheet brought into contact, which may be either substantially static contact or substantially intimate rolling contact, with the acceptor element is the donor sheet portion located between the first and second contact rollers. Preferably, the first and second contact rollers are spring loaded contact rollers.

[0016] In accordance with another exemplary embodiment of the present invention, the first contact roller is located proximate to the dispensing roller and the second contact roller is located proximate to the receiving roller.

[0017] In accordance with another exemplary embodiment of the present invention, the cylindrical drum, dispensing roller, receiving roller and contact rollers rotate in a synchronous manner.

[0018] In accordance with another exemplary embodiment of the present invention, the laser-induced thermal transfer printer comprises a laser imaging head for providing scanning laser energy to transfer material from the donor sheet to the acceptor element to form a representation of an image on the acceptor element, and the portion of the donor sheet brought into contact with the acceptor element is the donor sheet portion located generally proximate to the laser imaging head.

[0019] In accordance with another exemplary embodiment of the present invention, contact rollers are not utilized. This exemplary embodiment includes a rotatably mounted cylindrical drum, an acceptor element which is an acceptor sheet affixed to and supported by the cylindrical drum, a rotatably mounted dispensing roller for dispensing a donor sheet, and a rotatably mounted receiving roller for receiving the donor sheet. The donor sheet is located between the dispensing roller and the receiving roller, and the dispensing roller and receiving roller are configured to bring a portion of the donor sheet located therebetween into contact, which may be either substantially static contact or substantially intimate rolling contact, with a portion of the acceptor element.

[0020] The surfaces of the donor sheet and of the acceptor element are usually uneven, so that the donor and acceptor elements define both contact points and non-contact areas between the surfaces. This is particularly so when the acceptor element is an acceptor sheet. In the non-contact areas, the two surfaces are separated by small gaps. Unlike the case of thermal resistor head imaging, where material transfer occurs only in the contact points, in the present invention material transfer may take place even across a small gap. This occurs because the material being transferred from the donor sheet possesses some momentum due to the rapid thermal expansion and production of gaseous species. Therefore, material and image transfer in the present invention occur across both contact points and non-contact areas defined by the donor sheet and acceptor element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Further objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing illustrative embodiments of the invention, in which:

[0022] Figures 1-3 depict exemplary prior art laser-induced thermal transfer printer devices.

[0023] Figures 4-5 illustrate exemplary embodiments of the laser-induced thermal transfer printing device of the present invention, in which contact rollers are utilized to bring a donor sheet into contact with an acceptor element, where the acceptor element is an acceptor sheet.

[0024] Figure 6 illustrates schematically how the pressure applied to the drum by the sheet varies along the drum segment in the laser-induced thermal transfer printing device of the present invention.

[0025] Figure 7 illustrates another exemplary embodiment of the laser-induced thermal transfer printing device of the present invention, in which contact rollers are not utilized to bring the donor sheet into contact with the acceptor element, where the acceptor element is an acceptor sheet.

[0026] Figures 8-9 illustrate other exemplary embodiments of the laser-induced thermal transfer printing device of the present invention, in which a supporting drum is associated with the acceptor element in the form of a continuous web.

[0027] Figure 10 illustrates another exemplary embodiment of the laser-induced thermal transfer printing device of the present invention which is suitable for color proofing.

[0028] Figure 11 illustrates another exemplary embodiment of the laser-induced thermal transfer printing device of the present invention in which the acceptor sheet may be cut before the receiver roll is imaged.

[0029] Figures 12-13 show a prior art embodiment of a method to avoid image skewing in a continuous scanning mode.

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DETAILED DESCRIPTION OF THE INVENTION

[0030] Preferably, the apparatus comprises a projection area, and contact between the portion of the donor sheet and the portion of the acceptor element covers a substantial arcuate section comprising the projection area. The term "projection area" as used herein is intended to indicate the area on which the laser beam impinges. The contact between the portion of the donor sheet and of the acceptor element is achieved by simultaneously driving the two portions at the same speed along an arcuate section of the rotatably mounted cylindrical drum upstream of the projection area, whereby the portion of the acceptor element and the portion of the donor sheet move in unison. Preferably, the apparatus does not require pressure plates to achieve contact between the donor sheet and the acceptor element. This arrangement insures that there is no relative displacement between said portions in the arcuate section upstream of the imaging area. At a given tension value in the donor ribbon, the pressure between the donor sheet and receiving roller increases with decreasing radius of curvature.

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[0031] Fig. 1 depicts a schematic representation of prior art components in the field of laser induced thermal transfer printing. In this figure, block 310 represents the electronics, programs, memories, and modulators necessary for the production of laser beams in accordance with image signals as known in the laser printer art. Block 310 controls laser head 214 that projects image-representing rays to the surface of drum 300. A receptor sheet 302 is attached to the drum. A donor sheet 304 is pressed against the receiver sheet either by a vacuum, as described in U.S. Patent Nos. 5,257,038 and 6,204,874 (both of which are incorporated by reference herein) or by a mechanism attached to the ends of the donor sheet, as described in U.S. Patent No. 5,764,268

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(herein incorporated by reference) to establish an appropriate pressure to the whole page of the donor-receiver sandwich. In each of U.S. Patent Nos. 5,257,038, 6,204,874, and 5,764,268, as well as U.S. Patent No. 5,734,409, intimate contact between donor and acceptor material is obtained by various complex means. Although primarily dedicated to the production of color proofs, the arrangements described in these patents are equally applicable to the production of printing plates as mentioned in U.S. Patent No. 6,204,874.

[0032] Exemplary prior art embodiments also include laser-induced thermal transfer printing devices in which the entire imaging head resides on a carriage, such as is shown schematically in Figure 2, in which controls 1 and a laser and optics element 4 are positioned operatively with a continuously moving carriage 6 moving on a track 8, such that an imaging head 9 is used to provide an image 10 on the acceptor sheet 12 located on roller 14.

[0033] Fig. 3 is a schematic diagram of the laser-induced thermal transfer printing device described in U.S. Patent No. 4,804,975 (herein incorporated by reference). Unlike the embodiment of the present invention discussed in Fig. 4 below, in Fig. 3 there is no wrapping of the donor ribbon around an arcuate section of the drum. Instead, as described in U.S. Patent No. 4,804,975, donor and acceptor are hard pressed into close contact in the projection area by pressure plate 41 located between supply roller 21 and take-up roller 23. In contrast, no pressure plates are employed in the present invention.

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[0034] Fig. 4 illustrates a schematic diagram of an exemplary embodiment of the laser-induced thermal transfer printing device of the present invention. The extent of the wrapping of the sheet around the drum in Fig. 4 is defined by the angle β subtended at the center of the drum by the

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radii joining the center of the drum and the centers of contact rollers 212 and 212'. At a given tension value in the donor ribbon, the pressure between the donor and the receiver increases with decreasing radius of curvature. In the embodiments where a receiver sheet is affixed to the drum, a minimum drum size is dictated by the desired receiver sheet size. The contact pressure is controlled by the tension applied to the donor ribbon. The linear speed of the surface of the receiving element attached to the drum is kept identical to the linear speed of the donor sheet, regardless of the amount of material wound around the donor spools. Dispensing roller 208 is preferably controlled by a torque motor in order to maintain taut the section of the donor sheet between the roller 208 and roller contact 212'. Receiving roller 210 is preferably frictionally biased to take up any slack that may be present.

[0035] Fig. 5 depicts an end view of the exemplary embodiment of the laser-induced thermal transfer printer apparatus of Fig. 4. As depicted in Fig. 5, an acceptor sheet 202, such as a lithographic printing plate substrate for example, is affixed to the outer circumference of a cylindrical drum 38. A donor sheet 206 is provided by dispensing roller 208 and is received by receiving roller 210. Contact rollers 212 cause a portion of donor sheet 206 located between dispensing roller 208 and receiving roller 210 to be brought into contact with a portion of acceptor sheet 202 affixed to cylindrical drum 38, so that the donor sheet 206 is located between that portion of acceptor sheet 202 and the laser imaging head 214. The portion of donor sheet 206 which is brought into contact with acceptor sheet 202 by contact rollers 212 preferably includes only the area of acceptor sheet 202 and donor sheet 206 generally proximate to the portions thereof being scanned by the laser imaging head 214.

[0036] In one preferred embodiment of the invention, the donor sheet 206 may comprise a transfer layer comprising a photothermal converter. In another preferred embodiment of the invention, the donor sheet 206 may comprise a transfer layer and a layer adjacent to the transfer layer, wherein the layer adjacent to the transfer layer comprises a photothermal converter.

[0037] The dispensing roller 208, receiving roller 210, contact rollers 212 and cylindrical drum 38 rotate in a synchronous manner, so that the portion of donor sheet 206 and acceptor sheet 202 which are in contact with one another between contact rollers 212 move in tandem, in a substantially intimate rolling manner and with minimal slippage with respect to one another. In this way, tangential displacement and friction is minimized between the contacting portions of the donor sheet 206 and acceptor sheet 202.

[0038] Laser imaging head 214 provides the scanning laser energy necessary to transfer the desired material from donor sheet 206 to acceptor sheet 202, thereby forming the desired image on receptor sheet 202. The laser imaging head 214 typically performs the scanning function by travelling in a suitable guide track (not shown) parallel to the axis of the cylindrical drum 38. This is normally performed under the direction of a control unit (not shown) connected to laser imaging head 214. The same or another control unit connected to laser imaging head 214 typically provides suitable energy thereto to effectuate the desired transfer of material from donor sheet 206 to acceptor sheet 202. Image-generating data is typically provided to laser imaging head 214 by a control unit (not shown) which is connected thereto and which typically includes image memory.

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[0039] Laser imaging head 214 typically contains multiple laser beams for scanning the portion of the donor sheet 206 and acceptor sheet 202 being imaged. The focal spots of the lasers contained in laser imaging head 214 are typically configured to be located at or proximate to the interface between the portions of donor sheet 206 and acceptor sheet 202 located between contact rollers 212, and are configured to move in a reciprocating manner along the direction of the axis of cylindrical drum 38. Such movement of the laser focal spots typically is accomplished by appropriate movement of the laser-imaging head 214, or alternatively by rotating one or more mirrors located in the laser imaging head 214.

[0040] Figure 6 schematically represents the variation of pressure P applied to the drum by the sheet under media tension F along the drum segment where the media sheet contacts the drum. The media sheet M is wrapped on the drum segment between point A where it tangentially contacts the drum and the point A' where it leaves the drum. The maximum pressure is at the top S of the segment. At point S the pressure is given by the equation:

$$S = 2KF \sin \theta'$$

where K is a constant and θ' is the angle subtended at the center of the drum by the arc AP. Going clockwise from point S, the pressure gradually decreases to reach a minimum at point A' where the media leaves the drum. The pressure applied at different points such as P' along circular segment S-A' gradually decreases as a function of the angle α subtended at the center of the drum by the arc A'P'.

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[0041] Fig. 7 depicts an end view of another exemplary embodiment of the laser-induced thermal transfer printer apparatus 300 of the present invention. The exemplary embodiment depicted in Fig. 7 is similar to that depicted in Fig. 5, except that contact rollers 212 are not used to bring donor sheet 206 into contact with acceptor sheet 202. Instead, donor sheet 206 is brought into contact with acceptor sheet 202 by dispensing roller 208 and receiving roller 210, thereby eliminating the size, cost and complexity associated with contact rollers 212.

[0042] As depicted in Fig. 7, an acceptor sheet 202, such as a lithographic printing plate substrate for example, is affixed to the outer circumference of a cylindrical drum 38. A donor sheet 206 is provided by dispensing roller 208 and is received by receiving roller 210. Dispensing roller 208 and receiving roller 210 are configured to cause a portion of donor sheet 206 located therebetween to be brought into contact with a portion of acceptor sheet 202 affixed to cylindrical drum 38, so that the donor sheet 206 is located between that portion of acceptor sheet 202 and the laser imaging head 214. The portion of donor sheet 206 which is brought into contact with acceptor sheet 202 preferably includes only the area of acceptor sheet 202 and donor sheet 206 generally proximate to the portions thereof being scanned by the laser imaging head 214.

[0043] The dispensing roller 208, receiving roller 210 and cylindrical drum 38 rotate in a synchronous manner, so that the portion of donor sheet 206 and acceptor sheet 202 which are in contact with one another move in tandem in a substantially intimate rolling manner and with minimal slippage with respect to one another. In this way, tangential displacement and friction is minimized between the contacting portions of the donor sheet 206 and acceptor sheet 202. The

operation and scanning functions performed by laser imaging head 214 are similar to those described above in connection with Fig. 5.

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[0044] Fig. 8 and 9 illustrate other exemplary embodiments of the laser-induced thermal transfer printing device of the present invention. The apparatus of Fig. 8 includes a donor sheet 206, a dispensing roller 208 and receiving roller 210, and contact rollers 212. The apparatus also includes a supporting drum 38 which is associated with the acceptor element in the form of a continuous web comprising a "blank" receiver spool 217, a receiver sheet 219 and an "exposed" receiver spool 218. The drum is made of light and rigid material and can rotate freely. It may be a support or it may be driven by a motor. In the apparatus of Fig. 9, contact roller 213 is a drive roller, and a second drive roller 215 contacts the surface of the drum 38 between drive roller 213 and imaged receiver spool 217. Contact roller 212 is a pressure roller, and a second pressure roller 216 contacts the surface of the drum 38 between pressure roller 212 and receiver supply spool 218. In Fig. 8 and 9, the extent to which contact is present between the donor and the receiver depends on the combination of the size of the arcuate contact area, the action of the rollers that maintain taut the section of the donor pressing against the drum, and the identity of the linear speed of the donor and receiver. In Figure 8, the two radii connecting the center of the drum and the centers of the two contact rollers define an angle α. Angle α is analogously defined in Figure 9. The larger the value of the angle α in Fig. 8 and 9, the more substantial is the arcuate area of contact between donor and acceptor.

[0045] Fig. 10 illustrates another exemplary embodiment of the laser-induced thermal transfer printing device of the present invention, in which a plurality of the printing device units of Fig. 5

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are connected by means of a plurality of transfer systems. The embodiment of Fig. 10 is especially suitable for color proofing, since donor-acceptor contact is limited to an area substantially smaller than a whole sheet of material. The acceptor element is affixed to a curved section of the cylindrical drum. In Figure 10, the curved section corresponds to about one-half of the circumference of the drum. This feature of the invention makes it possible to use material in roll form for the donor as well as for the acceptor. The embodiment described in Figure 10 takes advantage of the fact that laser induced thermal transfer does not require considerable pressure of donor to acceptor. The production of color proofs involves the serial passage of the receptor through four similar units shown at 101, 102, 103, and 104. These units differ only in that each one is dedicated to a different color, as determined by the donor material. For example, 101 can be dedicated to Cyan, 102 to Yellow, 103 to Magenta and 104 to Black. The "blank" receptor material can be supplied either in the form of sheets or roll as shown at 1000 and the exit of the "colored" receptor at 1002. Free-rotating transfer drums are shown at 105, 106 and 107. The supporting drums, that could be freely rotating or driven at a selected speed, are shown at 108, 109, 110 and 111. Similar thermal laser projection units are shown at 112, 113, 114 and 115. The angle θ represents the contact angle in which receptor and donor move in unison. Input rollers are shown at 116, 117, 118, and 119 and exit rollers at 120, 121, 122, and 123. The acceptor element or sheet is extended between a contact roller of one printing device unit and free-rotating transfer drum 105, 106, or 107, and the acceptor element or sheet is extended between the rotatably mounted transfer drum a contact roller of another printing device unit. The input supply of donor material is shown at 124 for Cyan, 125 for Yellow, 126 for Magenta and 127 for Black. The exit of used donor material is similarly show at 128, 129, 130, and 131.

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Accurate registration means are provided as is well known in the industry to insure the exact location and superposition of each color at each stage. Thus, Figure 10 schematically depicts a single-pass color-proofing unit representing a substantial progress in the printing field where a substantial number of colored pages is involved.

[0046] In contrast, in the arrangements described in U.S. Patent Nos. 5,257,038, 6,204,874, 5,764,268, and 5,734,409, to produce one single color sheet involving the superposition of four basic colors, it is necessary to go through four delicate and time-consuming manipulations in sequence (see, e.g., U.S. Patent No. 5,257,038, column 8, lines 9 to 36). This lengthy procedure has a detrimental effect on the production rate of proofs and involves many colored pages for several printing plates.

[0047] Fig. 11 illustrates another exemplary embodiment of the laser-induced thermal transfer printing device of the present invention. Fig. 11 is similar to Fig. 5 except that the acceptor sheet 202 is not affixed to the entire surface of the drum but rather may be cut before the entire receiver roll is imaged.

[0048] The imaging system comprises a plurality of independent controllable laser beams. If scanning is continuous, the combination of the movement of a laser beam and the rotation of the drum causes the dots forming the image to be skewed or non-symmetrically disposed. The skewing may be prevented as described in Figures 7 and 8A of U.S. Patent No. 4,819,018 (herein incorporated by reference), which correspond to Figures 12 and 13 herein, respectively. The solid lines of Figure 12 represent a series of four contiguous image areas or blocks 160 to 163 as they would appear on the film if the carriage were projecting the light emerging from only the

highest and the lowest gates in an array of light gates. The thin phantom lines such as 181 represent the traces that would be left on the film by the highest and lowest active light gates, in absence of any compensation. The direction of travel of the carriage is shown by an arrow in each block. The compensating means shifts the location of the active gates to keep the light from the uppermost active gate in synchronism with the film motion so that it moves in a straight line perpendicular to the edge of the film from position 160-1 (beginning of projection) to point 165 (end of projection). If no compensation were made, point 165 would be at 160-2. The curve followed by the light from the uppermost active gate if it were "on" during turn-around of the carriage is shown at 165'. The distance between point 160-2 and 165 represents the compensating value produced by the correction mechanism during the actual projection of the image block, and the distance between points 160-2 and 164 represents the distance traveled by the film during the turn-around time. Figure 13 illustrates two lines of text for which each sweep of the laser beam always starts at the left margin, 160a, with spacing such that the sweep accurately joins with the preceding sweep. In the first sweep defined by the left and right margins 160a and 161a, and dashed lines 165a and 166a, the computer previously will have stored instructions such that all of the characters in the first line of the example, "The quick brown fox jumped" over will be formed, except for the descenders or lower portions of the letter "q" and "j". The instructions stored for the next sweep defined by dashed lines 166a and 167a ensure that all of the characters "the lazy dog" will be formed during that sweep, except for the descenders of the letters "y" and "g" and the descenders of the first line. For the third sweep, defined by dashed lines 167a and 169a, the only instructions stored are those for the descenders of the letters "y and g". The addresses from which instructions are retrieved are shifted by one for every 100 vertical

lines in the sweep. By this means, the character portions between the solid lines 170a and 171a will be formed during the first sweep 162a; the character portions between lines 171a and 172a are formed during a second sweep 163a; and the character portions between lines 172a and 173a are formed during a third sweep 164a.

[0049] Although the present invention has been described in connection with specific exemplary embodiments, it should be understood that various changes, substitutions and alterations can be made to the disclosed embodiments without departing from the spirit and scope of the invention as set forth in the appended claims.